Drill column for deep wells

The present invention relates firstly to a drilling pipe in accordance with the common precharacterizing clause of Claims 1 and 5. Furthermore, the invention relates to a bush in accordance with the common precharacterizing clause of Claims 13 and 18. Furthermore, the invention relates to a drill column for deep wells in accordance with Claim 27.

DE 27 44 829 C2 has disclosed a drilling pipe having a drilling pipe body made from an electrically conductive material, in which an electrical pipe conductor is passed through and is connected to a contact connection arranged at one end on the drilling pipe body, the pipe conductor and the contact connection being electrically insulated from the drilling pipe body. In the case of the known drilling pipe, the electrical conductor is guided in a protective pipe. The protective pipe with the conductor extends in the longitudinal direction along the inner wall of the drilling pipe body and is helical and is pressed, in this form, in a resilient manner against the inner wall of the axial borehole of the drilling pipe body. However, the protective pipe and the conductor arranged within the protective pipe cannot be prevented from being adversely affected when flushed with drilling mud, in which case the drilling fluid is pumped through the drill string at a very high rate. Furthermore, tools which are left by the drill string remain suspended at the turns of the protective pipe and damage the protective pipe or the conductor.

The object of the present invention is to provide a drilling pipe, a bush and a drill column in each case of the type mentioned initially, with which it is possible to transmit electrical energy and/or data from the surface to the bottom of the borehole and back with a high degree of reliability and a low degree of susceptibility to faults.

The abovementioned object is achieved in each case by a drilling pipe of the type mentioned initially having the characterizing features of Patent Claims 1 and 5 and by a bush of the type mentioned initially having the characterizing features of Patent Claims 13 and 18. Furthermore, the object according to the invention is achieved by the drill column claimed in Patent Claim 27.

Owing to the design according to the invention of the drilling pipes on the one hand and bushes on the other hand in conjunction with the respective conductors and contact connections, a system results in which, when the drilling pipes are connected to the bushes in order to extend the drill column, in each case an electrically conductive connection results via two poles. In this case, one pole is formed by the drill column body and the other pole is formed by the conductor arranged therein. This then makes it possible to transmit electrical energy from the surface to any desired point in the borehole and to transmit data via the conductor to the surface without any delay. The conductor can be made from such a material that both energy and data transfer is possible.

The drilling pipes and the bushes, as far as the arrangement of the conductor is concerned, have essentially the same design. In a first embodiment of the invention, in accordance with Patent Claims 1 and 13 provision is made for the pipe conductor to be fixed to the pipe inner side or for the bush conductor to be fixed to the bush inner side. It is therefore necessary for them to be fixed in the column interior since some of the drilling mud is pumped through the drill column string at a very high speed and this could result in the conductor being adversely affected if there is insufficient fixing. In order to reliably protect the conductor within the column, a longitudinal groove is

provided on the pipe inner side of the drilling pipe body or on the bush inner side of the bush body. The groove can be realized, both in the case of new drilling pipes and bushes and in the case of those which have already been used, by means of a corresponding special device such that the invention can also easily be implemented retrospectively. The conductor in the string interior is protected by the groove, which preferably runs parallel to the centre axis of the column, to be precise in particular if the depth of the groove is greater than the diameter of the conductor, with the result that the conductor is completely accommodated in the groove. Furthermore, in order to fix the conductor in the groove, said conductor should be cast in via an insulation. In addition, it is moreover possible to completely sheath the conductor by means of a corresponding conductor insulation in order to ensure the required electrical insulation. Moreover, in order to electrically insulate the string interior from the string exterior, an electrical insulating layer is applied, in particular vapour-deposited, over the entire surface of the pipe inner side, in which case the insulating layer should preferably cover the conductor.

In another embodiment of the invention, in accordance with Patent Claims 5 and 18 provision is made for the pipe conductor or the bush conductor to be tubular, for the pipe conductor or the bush conductor to be passed through the drilling pipe body or the bush body and/or to sheath the drilling pipe body or the bush body, and for, preferably, the pipe conductor or the bush conductor and the drilling pipe body or the bush body to have essentially the same linear thermal expansion behaviour, the design of the drilling pipe according to the invention being described below. The described features are correspondingly transferable to the bush according to the invention. The bush has a corresponding design to that for the drilling pipe. It

is essential that an inner pipe and/or outer pipe is provided as the pipe conductor or bush conductor, energy and data being transmitted from the surface to the bottom of the borehole and back via said inner pipe and/or outer pipe.

In order to ensure the transmission of energy and data even at considerable drilling depths, provision is preferably made for the pipe conductor or the bush conductor and for the drilling pipe body or the bush body to have essentially the same linear thermal expansion behaviour. The linear thermal expansion behaviour, defined by the coefficient of linear expansion α, indicates by how much the length of an object increases if the temperature of the object is increased by 1°C. If the pipe conductor has a comparable or even identical linear expansion behaviour to the drilling pipe body, there is no axial displacement of the pipe conductor in relation to the drilling pipe body even at considerable drilling depths. There is therefore no danger of the energy and data transmission being disrupted or interrupted owing to the pipe conductor and the drilling pipe body having different degrees of linear expansion. In this context, the pipe conductor and the drilling pipe body may be produced from the same material, preferably from steel, for reasons of simplicity. In principle, however, it is also possible for an alloy which has an appropriate linear expansion behaviour to be used as the material for the pipe conductor.

In order to provide a fixed connection between the pipe conductor and the drilling pipe body, the pipe conductor can be connected to the drilling pipe body in a cohesive and/or force-fitting manner. For example, it is possible to adhesively bond the pipe conductor to the drilling pipe body. It is just as easily possible for a slotted sleeve to be inserted, as the pipe conductor, into the drilling pipe body, in which case

it is necessary to correspondingly compress the outer surface of the sleeve in order to make it possible to insert the sleeve in the drilling pipe body. The resetting forces in the outer surface of the sleeve result in a force-fitting connection between the sleeve and the drilling pipe body in said drilling pipe body. It is naturally also possible just as easily for the drilling pipe body to be shrunk onto the sleeve.

A gap of 0.5 cm to 2.5 cm, in particular a gap of 1.5 cm, is preferably provided between the pipe conductor and the drilling pipe. The gap can be filled with a casting compound, in particular a plastic, preferably with epoxy resin. The casting compound firstly produces a cohesive bond between the pipe conductor and the drilling pipe and also acts as an insulating layer. The inside outer surface of the pipe conductor is preferably coated with a further insulating layer. If, on the other hand, provision is made for the pipe conductor to sheath the drilling pipe body, the outer side of the pipe conductor can be coated with an electrically nonconductive material.

Since the line resistance of the pipe conductor increases as the length of the pipe increases, the wall thickness of the pipe conductor is preferably fixed as a function of the maximum drilling depth. In this case, a wall thickness for the pipe conductor of 0.5 mm to 1.5 mm, in particular of 0.7 mm to 1.2 mm, may preferably be provided up to a drilling depth of 2000 m. If, on the other hand, it is intended to drill up to depths of 5000 m, a pipe conductor having a wall thickness of 4 mm to 8 mm, preferably 5 mm to 6 mm, can be used. The above-described features of the pipe conductor or bush conductor according to the invention allow for energy to be transmitted at a low voltage or a very low voltage of preferably 42 volts.

If the conductor is provided in the interior of the drill string, it is possible for the pipe contact connection to be provided on the end-side front face of the drilling pipe body. The end-side front face in this case represents a shoulder towards the pipe inner side. In order to be able to interact with the pipe contact connection, the bush contact connection is provided on a front-side shoulder towards the bush inner side. When the mechanical connection is made, i.e. when the drilling pipe and the bush are screwed together, an electrical connection is then produced between the pipe conductor on the one hand and the bush conductor on the other hand via the contact connections on both sides.

Since the drilling pipes are generally screwed to the bushes, it is particularly advantageous for both the pipe contact connection and the bush contact connection to be of circumferential design, i.e. to be in the form of contact connection rings. In order to ensure electrical insulation between the respective contact connection and the drilling string body, in this case the pipe contact connection should be arranged on an insulating ring resting on the front face, while the bush contact connection should be arranged on an insulating ring resting on the shoulder. In order in this case to ensure sufficient insulation not only from the drill column body but also from the interior of the drill string and the mud located therein during the drilling operation, the insulating ring, which should be made from an elastic material, should have an annular groove for the purpose of accommodating the respective contact connection, in which case the annular groove should be deeper than the height of the contact connection. This ensures that, when the drilling pipes are screwed to the bushes, there is a sufficient seal at the mutually facing surfaces of the insulating rings owing to these rings being pressed together when simultaneous contact is made with the contact connections.

Since, in the case of very long drill columns, which may have a length of several thousand metres, it is possible for longitudinal movements between the bushes and the drilling pipes to result, a possible solution is for the contact connections to be spring-loaded in particular in the direction away from the front face or the shoulder. Owing to the spring-loading, the contact connections are pushed towards one another such that any movements of the drilling pipes and adjacent bushes cannot result in an interruption of the electrical contact between the contact connections.

Moreover, in order to prevent the drilling mud from passing from the annular space into the intermediate space between the contact connections, at least one circumferential seal should be provided in the region of the pin of the drilling pipe body. The seal is preferably located at the step from the pipe outer side to the pin and/or at the transition from the step to the pin. One or more seals can also be provided in the region of the pin itself. On the bush, a possible solution is to provide at least one circumferential seal on the outer front face of the bush body.

It goes without saying that it is possible with the invention for not just one conductor but a plurality of conductors to be provided in the drill column. Since the conductors cannot be selected to have any desired size in terms of their diameter in order not to take into account any weakening of the drill column which is too severe by means of grooves on the inner side of the drill column which are too deep, the number of conductors which generally in any case have a small diameter is determined as a function of the electrical energy requirement for operating the respective measuring and analysis instrument located in the borehole.

Exemplary embodiments of the invention will be described below with reference to the drawing, in which:

Figure 1 shows a schematic view of a drill column introduced into a borehole,

Figure 2 shows a schematic view of the pipe end of a drilling pipe,

Figure 3 shows a schematic view of part of a bush,

Figure 4 shows a cross-sectional view of part of a drilling pipe,

Figure 5 shows a detailed view of part of a drilling pipe,

Figure 6 shows a detailed view of a bush,

Figure 7 shows a schematic partial view of a drilling pipe, which has been screwed into a bush, having a pipe conductor or bush conductor fixed in a groove, and

Figure 8 shows a schematic partial view of a drilling pipe having a tubular pipe conductor.

Figure 1 is a schematic illustration of a drilling apparatus 1. The drilling apparatus 1 has a drilling head 2 arranged at the surface and a drill column 3, which is located in a borehole 4 in the drilling state. A bit unit 5 is located at the other end of the drill column 3. In the exemplary embodiment illustrated, a measuring device 6, which is connected to an evaluation device 8 located at the surface via a conductor 7, is located directly above the bit unit 5. The measuring device 6 makes it possible to record measured values

during drilling which can then be evaluated directly via the evaluation device 8.

The drill column 3 itself in this case comprises a large number of alternately arranged drilling pipes 10 and bushes 11. Drilling pipes 10 of the type in question may have a length of up to 10 m or longer, while drill columns 3 for deep wells may have a length of several thousand metres.

Figure 2 and the detailed illustration shown in Figure 4 illustrate part of a drilling pipe 10. The drilling pipe 10 has a drilling pipe body 12 made from an electrically conductive material. Provision is now made for at least one electrical pipe conductor 7a to be passed through the drilling pipe body 12, said electrical pipe conductor 7a being connected at the end, to be precise at both ends, to a pipe contact connection 13 provided on the drilling pipe body 12, the pipe conductor 7a and the pipe contact connection 13 being electrically insulated from the drilling pipe body 12. As can be seen in particular in Figure 4, the pipe conductor 7a is fixed to the pipe inner side 14. For this purpose, a longitudinal groove 15 for the pipe conductor 7a is provided on the pipe inner side 14. In this case, the groove 15 is dovetailed. In principle, however, any other groove shape is also possible. The groove 15 runs parallel to the centre axis of the drilling pipe 10. The depth of the groove 15 is in this case greater than the outer diameter of the pipe conductor 7a. The pipe conductor 7a is held in the groove 15 via an insulation 16. In addition to its fixing function, the insulation 16 also has an electrically insulating function. In addition to the insulation 16, the pipe conductor 7a has a conductor insulation 17 which extends over the entire length of the pipe conductor 7a. As can further be seen in Figure 4, an electrical insulating layer 18 is vapour-deposited over the entire surface of the pipe inner

side 14 and also covers the groove 15 and thus the pipe conductor 7a. The insulating layer 18 is applied over the entire surface of the pipe inner side 14.

The pipe contact connection 13 is provided on the end-side front face 19 of the pipe end of the drilling pipe 10. In this case, it goes without saying that in each case one corresponding pipe contact connection 13 is provided at both ends of the drilling pipe body 12, even if this is not specifically described below. The pipe contact connection 13 is of circumferential design and has the form of a contact ring. Moreover, the pipe contact connection 13 is arranged on an insulating ring 20 resting on the front face 19. The insulating ring 20, which is made from an elastic material, has an annular groove 21 for the purpose of accommodating the pipe contact connection 13. In this case, the annular groove 21 is deeper than the height of the pipe contact connection 13.

Moreover, the pipe contact connection 13 is in this case spring-loaded in the direction away from the front face 19, namely in the direction towards the bush 11 to be connected to the drilling pipe 10.

A pin 22, on which an external thread 23 is provided, is located at both pipe ends of the drilling pipe 10. A step 24, which merges at its end with the pipe outer side 25, is located between the pins 22 having the external thread 23. A circumferential seal 26, which in this case is an O ring, is located at the transition between the step 24 and the external thread 23. In place of the seal 26 or in addition to said seal, an annular seal can also be arranged on the step 24.

Figure 3 and the detailed illustration shown in Figure 6 illustrate part of a bush 11. The bush 11 has a bush body 27 made from an electrically conductive material. An electrical bush conductor 7b is passed

through the bush body 27 and is connected at the end, to be precise at both ends of the bush body 27, to bush contact connections 28, even if this is not specifically illustrated. The bush conductor 7b and the bush contact connections 28 are electrically insulated from the bush body 27.

The bush conductor 7b is fixed to the bush inner side 29. For this purpose, a longitudinal groove 30 is provided on the bush inner side 29 of the bush body 27. The groove 30 has the same design as the groove 15. Moreover, the groove 30 runs parallel to the centre axis of the bush 11. The illustration does not show the fact that the bush conductor 7b is cast into the groove 30 via an insulation and moreover is sheathed by a conductor insulation. Furthermore, an electrical insulating layer 31 is vapour-deposited on the bush inner side 29 and on the pipe inner side 14, said electrical insulating layer 31 also covering the bush conductor 7b.

As can be seen in particular in Figure 6, the bush contact connection 28 is provided on a front-side shoulder 32. The shoulder 32 is located between the internal thread 33 and the bush inner side 29. The bush contact connection 28 is of circumferential design and is arranged on an insulating ring 20 resting on the shoulder 32. The insulating ring 20 corresponds in terms of type and design to the insulating ring 20 provided on the drilling pipe 10, i.e. has an annular groove 21 for the purpose of accommodating the bush contact connection 28, in which case the annular groove 21 is deeper than the height of the bush contact connection 28. Moreover, the bush contact connection 28 is spring-loaded in the direction away from the shoulder 32. The spring-loading can be designed with respect to the contact connections 13, 28 such that one or a plurality of springs, for example small helical compression springs, act on the respective underside of

the contact connection. Furthermore, spring tongues can be provided on the respective contact connection. The spring tongues may in principle point inwards and/or outwards, it then being possible for outwardly pointing spring tongues to protrude beyond the actual contact connection and cause the electrical contact to be made.

In this case, a circumferential seal 35 is located on the outer front face 34 of the bush body 27. The outer front face 34 is located between the internal thread 33 and the bush outer side 36.

The drilling pipes 10 and bushes 11 as described above in conjunction with the pipe conductors 7a and bush conductors 7b result in a two-pole energy and data transmission system via the drill column 3. In this case, one pole is formed by the drill column body, which comprises the drilling pipe bodies 12 and the bush bodies 27, while the other pole is formed by the conductor 7, which comprises the pipe conductors 7a and the bush conductors 7b as well as the contact connections 13 and 28. The system according to the invention moreover has the advantage that the drill column 3 and thus the two poles can be extended as desired since screwing a drilling pipe 10 to a bush 11 provides the electrical connection via the contact connections 13, 28 on the one hand and via the material of the drilling pipe body 12 and of the bush body 27 on the other hand.

Energy is supplied to and data tapped off from the conductor 7 via a slipring collector (not illustrated), which is provided on the first drilling pipe 10. The slipring collector is connected to the pipe conductor 7a and insulated from the drilling pipe body 12. The slipring collector in turn is connected to the evaluation device 8, while the drill column body forms the connection to earth.

Figure 8 illustrates a schematic partial view of a drilling pipe 10 having a tubular pipe conductor 7a. The pipe conductor 7a is adhesively bonded to the pipe inner side 14 over the entire surface via an insulating layer 37. The insulating layer 37 may be, for example, epoxy resin, which ensures electrical insulation of the pipe conductor 7a from the drilling pipe 10 and with which the gap between the pipe inner side 14 and the pipe conductor 7a is cast. Furthermore, a further insulating layer 38 is provided on the inside outer surface of the pipe conductor 7a and is preferably coated with an electrically nonconductive material having a low surface roughness. A low-friction coating of the pipe conductor 7a in the interior contributes to a low flow resistance when there is a flow passing through the drilling pipe 10 during the production operation or during the flushing operation. The embodiment illustrated in Figure 8 of a drilling pipe 10 having a tubular pipe conductor 7a can correspond to the design of the bush 11 having the tubular bush conductor 7b. The contact connections of the drilling pipe 10 and the bush 11 essentially correspond to the above-described embodiments when the pipe conductor 7a or the bush conductor 7b is in each case guided in a longitudinal groove 15, 30, in which case it is necessary to ensure that the respective contact connection is electrically insulated from the drilling pipe 10 or the bush 11. In the case of a tubular design, the pipe conductor 7a and the bush conductor 7b can have a collar at the end in order to produce a line contact in a simple manner.